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Why Won't You Do What's Good for You? Using Intelligent Support for Behavior Change

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Abstract. Human health depends to a large extent on their behavior. Adopting a healthy lifestyle often requires behavior change. This paper presents a computational model of behavior change that describes formal relations between the determinants of behavior change, based on existing psychological theories. This model is developed to function as the core of a reasoning mechanism of an intelligent support system that is able to create theory-based intervention messages. The system first tries to determine the reason of the occurrence of the unwanted behavior by asking short questions via a mobile phone application and by gathering information from an online lifestyle diary. The system then attempts to influence the user using tailored information and persuasive motivational messages.

1 Introduction

A good health requires a healthy lifestyle. However, it is not easy to find (and keep) the optimal balance between work, a social life and, for example, a healthy diet or medicine schedule. Moreover, people with a chronic disease have extra barriers to overcome, such as physical discomforts and side-effects of medicine intake. In short, people have lots of reasons not to do what's good for them. As a consequence, the amount of people that have obesity or a chronic disease such as diabetes type 2 has increased considerably over the past years [28].

It has been shown that patient engagement and empowerment could improve patient therapy adherence and consequently their health condition [18]. This engagement and empowerment is often referred to as *self-management*: the individual's ability to monitor one's condition (symptoms, treatment) and to effect the cognitive, behavioral and emotional responses necessary to maintain a satisfactory quality of life [4]. But how can we get patients to increase their self-management? The use of computers to support people with their self-management has proven to be an effective approach [33,17]. These systems are able to provide personalized (*tailored*) interventions at low costs [8] and at home [27]. Interventions that are closely tailored to the individual's convictions and motivations have shown to be more likely to be read and remembered [29].

Although intelligent persuasive assistants are increasing popularity for the use of behavior interventions, those assistants are rarely based on formal models of behavior change. In their 2008 article, Michie, Johnston, Francis, Hardeman and

Eccles stated that: “Ideally, researchers designing interventions would choose a small number of the theoretical frameworks based on empirical evidence of their predictive and intervention value, i.e., there should be evidence that the theory can predict the behaviour and that interventions which change these determinants achieve change in behavior.” [20] In literature however, very few works can be found that provide a model based on formal theories. One notable exception is the the iChange model [34], which describes the factors that influence behavior change, but fails to explicate how these factors interact. Yet in order to design an effective support system, it is necessary to take a closer look at the underlying mechanisms of behavior change and how they can be influenced to establish the desired behavior. The current paper addresses this and presents a computational model based on theoretical frameworks of behavior change. It is used by an intelligent support system to understand human behavior and to detect the cause of unhealthy behavior, which enables the system to provide users both tailored information and persuasive motivational messages on how to improve their behavior.

An overview of approaches for intelligent support systems is provided in Section 2. In Section 3 a model that formalizes the interaction between the different determinants of behavior change is presented. Section 4 demonstrates how this model can function as the basis of an intelligent system that is able to provide support for individuals with a health condition (such as diabetes, HIV or obesity) by stimulating their self-management. Section 5 concludes the paper and gives some implications for further research.

2 Approaches for Intelligent Coaching and Mobile Persuasion

In order to point out the differences between the proposed system and other approaches, this section provides a brief overview of existing approaches for intelligent coaching. The main component of many contemporary approaches is the mobile phone, as they are easily available to the user and support both user and system initiated interactions. Also, information provided by the mobile phone can be personalized and can even be designed to persuade or manipulate [10]. Because of these capabilities, the mobile phone is an ideal platform to provide us with the power to induce behavior change [10]. Mobile phones and web-based interfaces have proven to be very effective in similar approaches [10].

The simplest of the approaches to induce behavior change are ‘reminder systems’, which do not use complex persuasive techniques but instead use simple messages to remind the patient of the desired behavior (e.g., [1,7]). For example, CARDS (Computerized Automated Reminder Diabetes System) [12] sends diabetic patients SMS messages and e-mails with reminders about blood monitoring, without further medical advice from a healthcare team. Under this category fall also the popular mobile phone and web-based applications that help patients keep track of data such as calorie intake, blood monitoring and exercise by means of an online mobile diary (e.g., [15,30]).

More complex systems are able to provide tailored feedback based on user data that is gathered by sensors (such as an accelerometer or GPS) or user input (such as a dairy function). Most systems use some kind of human coaching to supplement their system (e.g., [5,23]). The ODA (Online Digital Assistance) system [32], for example, is developed to support self-management of patients with chronic migraine by training behavioral attack prevention. ODA combines a mobile electronic diary with direct human online coaching, based on the diary entries. Persuasive systems that do not rely on human coaches (that is, while the system is active; healthcare professionals can still be part of the design process), are less common. Recently, this area has been given more attention. The system developed by D. Preuveneers and Y. Berbers in [24] assists diabetic patients to keep track of their food intake, blood glucose levels and insulin dosage. It uses relevant user context and activities (provided by user input and GPS) to learn trends and give tailored advice to the user. As another example, the persuasive computer assistant implemented by Blanson Henkemans et al. uses an online lifestyle dairy to improve exercise behavior of people who are overweight [13]. This assistant follows the principles of motivational interviewing and offers support by monitoring the dairy and providing tailored feedback.

All mentioned studies stress the potential of mobile and online support for patient self-management. The system presented in this work differs from previous approaches in that it does not only target the user's behavior, but also the underlying mechanisms causing that behavior. Because the system uses a computational model based on the theoretical frameworks of behavior and behavior change, it is able to provide tailored feedback that is not just focused on displayed behavior, but on the underlying individual cause of non-adherence. Furthermore, the system uses validated persuasion techniques without having to rely on a human coach, and combines support on three lifestyle domains: medicine, diet and exercise.

3 Modelling Behavior Change

3.1 Theories on Behavior Change

For health interventions to be effective, they need to incorporate existing theories on behavior change and persuasive design. The model of behavior change designed in this work is based on several existing models from psychology literature that describe determinants for behavior change. This section will describe their key constructs and how they are combined.

The Transtheoretical Model (TM) [25] forms the basis for the proposed model of behavior change. This model was successfully applied in many programs aiming at the elimination of addictive behavior, improving mental health, exercise, and dietary change [2,26]. It assumes that behavior change is a five-stage process with the stages of *precontemplation*, *contemplation*, *preparation*, *action*, and *maintenance*. Depending on the awareness, motivation and commitment of an individual, he or she progresses through the stages. In the precontemplation stage individuals have no intention to change their behavior and will likely be

unaware of their problems. In the contemplation stage individuals are aware that a problem exists and are seriously thinking of changing their behavior in the next six months, but they do not have any concrete plans of change. Individuals are defined as precontemplative when they are intending to take action in the next month but have not or not successfully taken action in the past year. During the action stage individuals modify their experiences and environment in order to overcome their problems and actively changing their behavior. Those who have engaged in a new behavior for more than six months are classified as being in the maintenance stage. Although a person advances through the stages in sequential order, relapse to a previous stage is possible. For an elaborate description of the separate stages, see [25].

According to the **Social Cognitive Theory (SCT)** of Bandura [3] behavior is executed if one perceives (i) control over the outcome, (ii) few external barriers and (iii) confidence in one's own ability. Bandura introduces a new concept that relates to the expectancies concerning the outcome: *self-efficacy*, defined as confidence in one's own ability to carry out a particular behavior. The concept of self-efficacy has shown to be a good predictor of behavior, related to coping with stress and recovery from illness [2].

Self-Regulation Theories (SRT) regard an individual as an active problem solver whose behavior reflects an attempt to close the gap between his current status and a goal. Levental's self-regulation model of illness identifies 3 stages of variables regulating the adaptive behavior: cognitive representation, action plan, *coping* and appraisal stage [22]. Important aspect of this approach is the possible influence of emotions, or *mood*, on behavior.

The Theory of Planned Behavior (TPB) is a revised version of the **Theory of Reasoned Action (TRA)** that was proposed by Fishbein and Ajzen [9]. The Theory of Reasoned Action is based on the assumption that *intention* is an immediate determinant of behaviour, and that intention, in turn, is predicted from *attitude* (which is a function of the *beliefs* held about the specific behaviour, as well as the evaluation (value) of the likely outcomes) and (subjective) *social normative* factors. In a more recent version of the theory, the Theory of Planned Behavior, one more component was added: *perceived behavioral control*, which has a motivational effect on intentions. This version was an attempt to account for behaviour under 'incomplete' volitional control. There is substantial overlap between the concept of self-efficacy in Bandura's Social Cognitive Theory and the concept of behavioral control in the theory of Ajzen and Fishbein.

The Theory of Reasoned Action does not describe explicitly what the determinants of attitude formation are. The **Attitude Formation (AF)** theory defines *attitude* as an important aspect of behavior, influenced by the *beliefs* about an object (in this case, behavior), emotional connotations associated with the object, and social norms concerning this object in this case [31].

The Health Belief Model (HBM)[16] includes six determinants of behavior related to perception: *susceptibility*, *severity*, *benefits*, *barriers*, *motivation* and *cues* for action. According to this theory, a combination of perceived

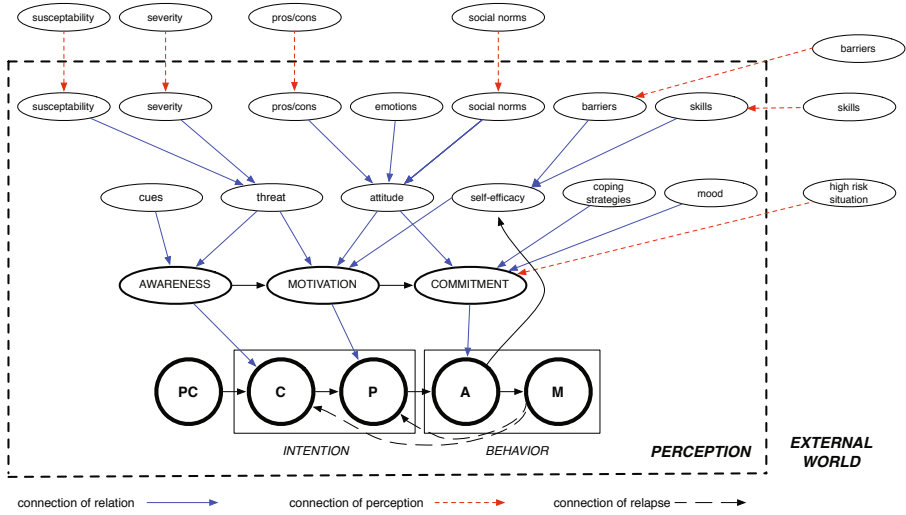


Fig. 1. The integrated model of behavior change COMBI

susceptibility with perceived severity produce perceived *threat*, and the combination of perceived benefits with perceived barriers produce evaluation of the course of action taken.

Marlatt and Gordon’s [19] **Relapse Prevention Model (RPM)** describes the influence of environmental factors along with the cognitive determinants, such as *self-efficacy* and *coping*. The emphasis lies on *high risk situations* and the ability of *coping* with them. The theory provides an explanation of relapse from the acquired behavior stage to the stage of the previously performed behavior in the terms of the Transtheoretical Model.

3.2 Integrated Model: COMBI

It is evident that there is a lot of overlap between the existing theories of behavior change, and many of the theories use similar constructs with sometimes different names. The COMBI model –which stands for Computerized Behavior Intervention– is an attempt to integrate these theories (see Figure 1) into a formal representation.

The description of all factors and the theories they originate from can be found in Table 1. The model differentiates between the internal and external determinants of behavior. External factors are depicted beyond the dotted line, these are *susceptibility*, *severity*, *pros/cons*, *social norms*, *barriers*, *skills* and *high risk situation*. *Susceptibility* and *severity* represent how one perceives the severity of the consequences of the performed behavior and the likeliness of being affected by them, *pros/cons* correspond to the beliefs about the importance of healthy lifestyle. *Social norms* reflect the influence of culture and environment

Table 1. The concepts of the model and the related theories

concept	description	related theory
susceptibility	likeliness of being affected by behavior's consequences	HBM
severity	severity of the consequences of the behavior	HBM
pros/cons	beliefs about the importance of healthy lifestyle	TPB,AF,HBM
emotions	feelings concerning the behavior change	SRT
social norms	the influence of culture and environment of a person	TPB
barriers	practical obstacles that prevent behavior change	HBM
skills	experience and capabilities to overcome the barriers	TPB,SCT
cues	environmental or physical stimuli	HBM
threat	perceived (health) risk of continuing to perform behavior	HBM
attitude	mental state involving beliefs, emotions and dispositions	TPB,AF
self-efficacy	perceived behavioral control	SCT,TPB,RPM
coping strategies	the ability to deal with tempting situations and cues	SRT,RPM
mood	temporary state of mind defined by feelings and dispositions	SRT
high-risk situations	contexts/environments that influence a person's behavior	RPM
awareness	conscious knowledge of one's health condition, the health threat and the influence of current behavior	TM
motivation	incentives to perform goal-directed actions	HBM,TM
commitment	(intellectual or emotional) binding to a course of action	TM

of a person, and *barriers* correspond to real obstacles that prevent a person from adopting a healthy lifestyle. *Skills* determine how much experience and capabilities one has in order to overcome these barriers. *High risk situation* reflects the possibility of certain contexts to influence person's behavior. Examples of *high risk situations* are negative emotions as a result of an interaction with others, experienced pressure and some cues in the environment that lead to a particular behavior.

The stages of change from the Transtheoretical Model are represented as five circles with the initial letters of the names of the stages at the bottom of Figure 1. The *contemplation* and *preparation* stages ('C' and 'P', respectively) are embedded in the 'intention' block and *action* and *maintenance* stages ('A' and 'M', respectively) are embedded in the 'behavior' block. All internal factors that determine the stage of change of an individual consist of 3 layers, showing the causal hierarchy between them. The action stage has also a feedback loop to self-efficacy, in accordance with the Self-Regulation Theory.

3.3 Formalization and Simulations

The COMBI model has been implemented in the numerical simulation environment Matlab. In this section, the formalization of the model is described and some simulation results are provided as illustration.

The arrows in Figure 1 denote causal dependencies (with the exception of the arrows between the stages of change): they represent transitions from one state to another that occur if the value of a state exceeds a certain threshold. For example, if the value of awareness, motivation or commitment is greater than 0.5, a transition to the next relevant state occurs; if the value drops to the level lower than 0.5, the person relapses to the previous state. Dependences between the concepts are expressed by weighted sums:

Rule 1: Calculation attitude value

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If pros/cons have value V1
and emotions have value V2
and social norms have value V3
and connection strength between pros/cons and attitude has value w1
and connection strength between emotions and attitude has value w2
and connection strength between social norms and attitude has value w3
Then attitude will have value  $w1 * V1 + w2 * V2 + w3 * V3$ 

```

All other values in the model are calculated in a similar way. The formal model can be personalized by adjusting the links (connection strengths) between the determinants. For example, the behavior of some people is much more affected by mood or the lack of social support than that of others. The same argumentation holds for the transition from the external world to its perceived internal representation. By increasing or decreasing the connection strengths between the determinants, these personal variations can be accounted for. In principle, the relevant connections can be updated when a discrepancy is discovered between observed patient behavior and the predicted behavior from the model.

Figure 2 shows some simulation results displaying the interplay between the different determinants of the model. These simulations show that the model can account for behavioral phenomena found in psychology and sociology.

In Figure 2a it can be seen how the values of threat and cue contribute to the value of awareness. In this scenario (let's say it is about Alan), the threat Alan perceives – i.e., how likely he thinks it that he has this disease and how severe its consequences are for him – remains constant. However, his cues (physical discomforts) increase drastically, making him much more aware of the condition he is in, until his symptoms recede again. (This is a well-known phenomenon, see e.g. [11].) Take a look at Figure 2b for another scenario, Betty's. At $t=0$, both awareness and motivation are low. Betty then (at $t=8$ and $t=20$) receives some information about how changing her behavior can contribute to a better health. Thus, she becomes better informed about the positive and negative consequences of her behavior. Unfortunately, Betty's attitude (and hence motivation) improve only slightly on learning this new information, as other factors – such as emotions and social norms – are stronger determinants of her attitude. Figure 2c shows how the commitment of Carol fluctuates with her mood. Although the strong improvement in social support gives her commitment a little boost, her mood is the key determinant of her commitment.

4 Implementation

The model described in the previous section has been used as basis for an intelligent coaching system, called **eMate**. This section describes the system, explains how the model is used to reason about the state of the user, and how the system interacts with the user.

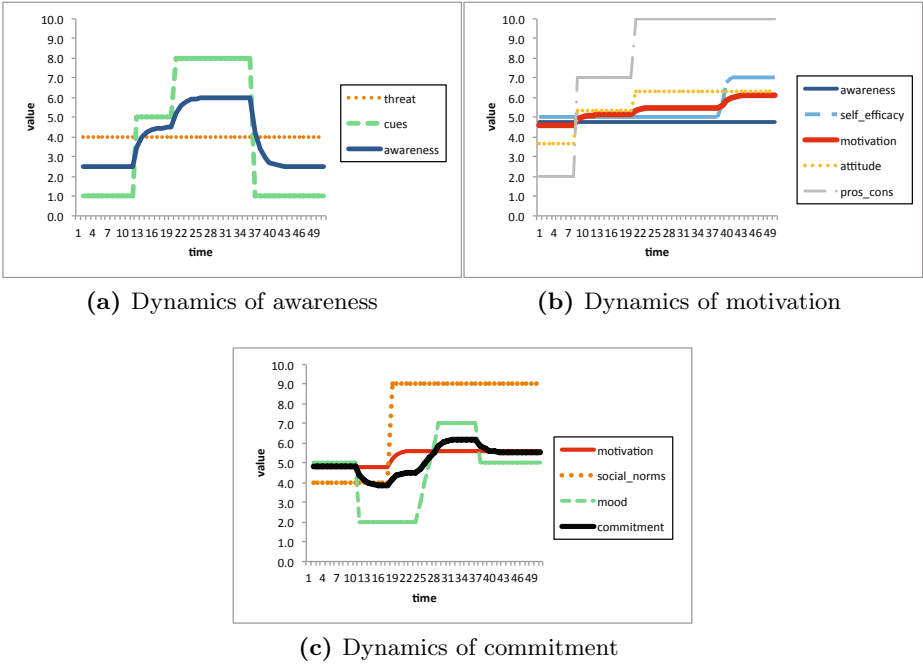


Fig. 2. Model dynamics

4.1 The eMate System

The **eMate** system aims to support patients with Diabetes Mellitus type II or HIV in adhering to their therapy, which consists of lifestyle advice and/or precise instructions for medication intake. Previous research has shown that a ‘cooperative assistant’ – i.e., with a coaching character, able to explain and educate, and expecting high participation of the user – is more effective than a ‘direct assistant’ – i.e., with an instructing character with brief reporting and low expectations on participation [14]. The **eMate** system therefore operates as a coach, using both a mobile phone and a website to interact with the user. Via the website, the user can get an overview of his progress on three different domains: medication intake, physical exercise, and healthy food intake. If one of the domains is not relevant for a specific user, it will be hidden. An overview shows the extent to which the user has reached his/her goals in the past week, which is represented as a percentage and a iconic thumb. See Figure 3 for an example. A mobile phone application for the Android platform has been developed that can pose questions and send messages to a user.

4.2 Model-Based Reasoning

The model is used to analyze the state of the patient with respect to his/her behavior change goals. It does so by investigating via simple questions which of the factors that influence behavior change are probably the most problematic for

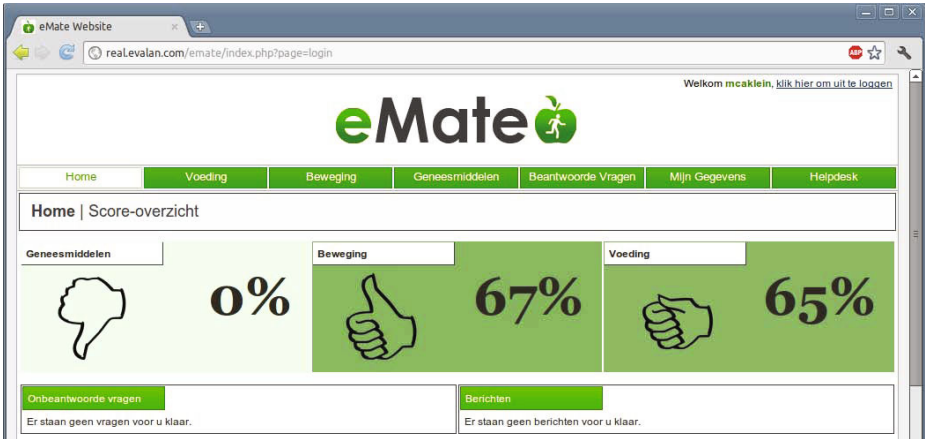


Fig. 3. Screenshot of the eMate website

this patient. This mechanism is called model-based diagnosis [6]. These factors are then targeted with specific messages and interventions. For this purpose the model has been translated into a rule-based representation that allows for backward reasoning over the psychological factors in the model. To achieve this, the rules relate factors in the model that have an ‘influence’-relation, i.e. if there is an arrow between two factors in the model (see Figure 1), a rule specifies that a low value of factor A could be caused by a low value of an influencing factor B. For example, two rules specify: ¹

“if threat has_value < 5 & threat is_hypothesis **then** severity set_hypothesis”
 “if severity is_hypothesis & has_value NULL **then** severity investigate”

The rules are implemented in a Java-based rules engine (Drools). Using these rules, the system determines for which psychological factors the value should be determined. This reasoning is performed on a regular basis and is done by posing specific questions about that concept from psychological surveys to the user. As some factors are more dynamic than others, the values will be redetermined after some time; the lifetime of the values is specified per factor. The user answers to the questions translate to values for each concept. These are stored in a database along with a timestamp of their determination. This way, the system maintains an up-to-date representation of the mental state of the user. The reasoning is performed separately for all domains that are active for a patient. However, some values, i.e. ‘mood’, ‘cues’, ‘skills’, ‘severity’, ‘susceptibility’ and ‘threat’ are considered to be equal for the different domains, and their value is automatically propagated to the other domains via the rules.

After this diagnostic phase, the system determines which factor should be targeted at to support the user in the most effective way. This is calculated by

¹ Note that the personalized parameters of the strengths between factors are ignored in this representation.

combining the ‘urgency’ of the value (how low the value is for a factor) with the ‘changeability’ of the factor, which is a parameter that represents to what extent the factor can be changed. For example, the social norms of a person are more difficult to change than the perception of the severity of the disease. Each week, the user will receive for each of the domains a summary of his behavior and a motivating message related to the factor on which the intervention should focus. The system contains several messages for each factor, so if the same factor is targeted in two subsequent weeks, the messages will still be different.

4.3 Questions and Messages

Due to the model-based reasoning, **eMate** is able to address the right problems at the right time. However, in order to persuade a user, the formulation of the queries and messages are also important. All messages are designed in such a way that the user won't be annoyed or bored by lengthy information messages (this approach is typical for tailored health messages that are commonly used in web-based solutions [17]). Furthermore, the motivational messages adhere to the principles of motivational interviewing, which have proven to be effective for purposes of coaching and therapy [21]. These principles focus on the social functioning of the user and on providing feedback by giving advice and direction. Expressing empathy, cheering and complimenting, and the support of self-efficacy and optimism, are some examples of the principles that are incorporated by the **eMate** system.

5 Discussion and Conclusions

This work presents the design and use of a computational model for behavior change. It has been shown that the model can be incorporated in a coaching system, which has a strong potential of providing support for individuals with respect to their lifestyles. The integrated model is an example of a causal modeling approach to developing complex, user-tailored interventions aimed at behavior change. **eMate** differs from other intervention approaches in that it targets the user's motivation and interests, and tailors intervention messages based on the underlying mechanisms of behavior change, thus attempting to understand the behavior.

Although developed for HIV and diabetes type II patients, it is expected that the flexible setup of the system is able to deal with other behavior change goals (such as quitting smoking or increasing the level of physical exercise for healthy persons), as the general mechanisms for these changes of behavior are similar to the ones implemented in **eMate**. Moreover, the rules and tailored messages can easily be changed to include different conditions and requirements. In the future, the model could also be used to predict the effect of an intervention, in order to let the system choose the most effective one.

Of course, the model is not able to capture every aspect of human behavior, as human behavior is the result of an interplay between different external

and internal factors, including biological, cognitive, environmental and socio-demographic factors. As the current model has been designed for intelligent health intervention applications that aim at behavior change, only the variables that are potentially amenable to change in the course of an intervention have been taken into consideration.

We intend to test and validate the model by setting up experiments with real users. A group of patients with either HIV or diabetes will be provided with the system. Behavior of this experimental group will be compared to a control group consisting of similar patients that were provided with only a website with static information about the importance of a healthy lifestyle and medication adherence. Validated pre- and post-questionnaires will be used to determine whether behavior change occurred in both groups.

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References

1. Anhoj, J., Nielsen, L.: Quantitative and qualitative usage data of an internet-based asthma monitoring tool. *Journal of Medical Internet Resources* 6(23) (2004)
2. Armitage, C.J., Conner, M.: Social cognition models and health behaviour: A structured review. *Psychology and Health* 15, 173–189 (2000)
3. Bandura, A.: Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review* 84(2), 191–215 (1977)
4. Barlow, J., Wright, C., Sheasby, J., Turner, A., Hainsworth, J.: Self-management approaches for people with chronic conditions: a review. *Patient Education and Counseling* 48, 177–187 (2002)
5. van den Berg, H.M., Rondaly, H.K., Peeters, A.J., van der Harst, E.M.V., Munneke, M., Breedveld, F.C., Vlieland, T.P.M.V.: Engagement and satisfaction with an internet-based physical activity intervention in patients with rheumatoid arthritis. *Rheumatology* 46(3), 545–552 (2007)
6. Davis, R.: Diagnostic reasoning based on structure and behavior. *Artificial Intelligence* 24(1-3), 347–410 (1984)
7. Downer, S.R., Meara, J.G., Costa, A.C.D.: Use of sms text messaging to improve outpatient attendance. *Medical Journal of Australia* 183(7) (2005)
8. Eysenbach, G.: What is e-health? *Journal of Medical Internet Research* 3(2)
9. Fishbein, M., Ajzen, I.: Belief, attitude, intention and behaviour: An Introduction to Theory and research. Addison-Wesley, Reading (1975)
10. Fogg, B.J., Eckles, D.: Mobile Persuasion, 20 Perspectives on the Future of Behavior Change. Stanford Captology Media (2007)
11. Halm, E.A., Mora, P., Leventhal, H.: No symptoms, no asthma*. *Chest* 129(3), 573–580 (2006)
12. Hanauer, D.A., Wentzell, K., Laffel, N., Laffel, L.M.: Computerized automated reminder diabetes system (cards): E-mail and sms cell phone text messaging reminders to support diabetes management. *Diabetes Techn. and Therapeutics* 11(2) (2009)

13. Henkemans, O.A.B., van der Boog, P.J.M., Lindenberg, J., van der Mast, C.A.P.G., Neerincx, M.A., Zwetsloot-Schonk, B.J.H.M.: Technology and Health Care 17, 253–267 (2009)
14. Henkemans, O.A.B., Rogers, W.A., Fisk, A.D., Neerincx, M.A., Lindenberg, J., van der Mast, C.A.P.G.: Usability of an adaptive computer assistant that improves self-care and health literacy of older adults. *Methods of Inf. in Medicine* 47, 82–88 (2007)
15. Inc., F.: Lose it! (July 2011), <http://www.loseit.com/>
16. Janz, N., Becker, M.: The health belief model: A decade later. *Health Education Quarterly*, 1–47 (1984)
17. Kreuter, M., Farrell, D., Olevitch, L., Brennan, L.: *Tailoring Health Messages: Customizing Communication With Computer Technology*. Lawrence Erlbaum Associates, Inc. (2000)
18. Maes, S., Karoly, P.: Self-regulation assessment and intervention in physical health and illness: A review. *Applied Psychology* 54(2), 267–299 (2005)
19. Marlatt, G., Gordon, J.: Determinants of relapse: Implications for the maintenance of behavior change, pp. 410–452 (1980)
20. Michie, S., Johnston, M., Francis, J., Hardeman, W., Eccles, M.: *Applied Psychology* 57(4) (2008)
21. Miller, W., Rollnick, S.: *Motivational Interviewing: Preparing People to Change Addictive Behaviour*. Guilford Press, New York (1991)
22. Nerenz, H.L.D., Steele, D.: Illness representation and coping with health threats. In: Baum, A., Singer, J. (eds.) *A Handbook of Psychology and Health*, pp. 219–252. Erlbaum Associates, Hillsdale (1984)
23. Philips: Directlife (July 2011), <http://www.directlife.philips.com/>
24. Preuvneers, D., Berbers, Y.: Mobile phones assisting with health self-care: a diabetes case study. In: *MobileHCI* (2008)
25. Prochaska, J., DiClemente, C.: *The Transtheoretical Approach: Crossing the Traditional Boundaries of change*. J. Irwin, Homewood (1984)
26. Prochaska, J., Norcross, J.: Stages of change. *psychotherapy: theory. Research and Practice* 38(4), 443 (2001)
27. Rogers, W.A., Mynatt, E.D.: How can technology contribute to the quality of life of older adults? In: Mitchell, M.E. (ed.) *The Technology of Humanity: Can Technology Contribute to the Quality of Life?*, pp. 22–30. Illinois Institute of Technology, Chicago, IL (2003)
28. Shaw, J., Sicree, R., Zimmet, P.: Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice* 87(1), 4–14 (2010)
29. Skinner, C., Campbell, M., Rimer, B., et al.: How effective is tailored print communication? *Annual Behavioral Medicine* 21, 290–298 (1999)
30. SkyHealth: Glucosebuddy (July 2011), <http://www.glucosebuddy.com/>
31. Smith, E., Mackie, D.: *Social Psychology*. Psychology Press, Philadelphia (2000)
32. Sorbi, M.J., Mak, S.B., Houtveen, J.H., Kleiboer, A.M., van Doornen, L.J.: Mobile web-based monitoring and coaching: Feasibility in chronic migraine. *Journal of Medical Internet Research* 9(5) (2007)
33. de Vries, H., Brug, J.: Computer-tailored interventions motivating people to adopt health promoting behaviours: introduction to a new approach. *Patient Educational Counseling* 36, 99–105 (1999)
34. de Vries, H., Mudde, A.: Predicting stage transitions for smoking cessation applying the attitude social influence efficacy model. *Psychology and Health* 13, 369–385 (1998)